

### REMARKS

The Examiner's careful review and examination of the subject application are noted and appreciated.

The present invention relates to a reversible hydrogen storage material comprising 80 to 99.9 weight percent of an aluminum hydride; and 0.1 to 20 weight percent of a catalytic material adapted to increase the kinetics of hydrogen absorption/desorption of the aluminum hydride without significantly reducing the hydrogen storage capacity of the aluminum hydride, the catalytic material comprising a hydrogen storage alloy, a Raney catalytic material, or combinations thereof.

Applicants have carefully reviewed the above-identified Office Action. Applicants contend that, in view of the clarifying remarks set forth herein, all bases of objection and rejection have been overcome. Accordingly, Applicants respectfully request withdrawal of the pending rejections and allowance of the claims submitted.

### SUPPORT FOR CLAIM AMENDMENTS

Claims 1 and 7 have been amended to read "a reversible hydrogen storage alloy." While "reversible" was not included in the claims as originally filed to describe the hydrogen storage alloy, such term is supported on page 10, lines 1-3 of the specification as originally filed.

### IN THE DRAWINGS

The objection to the drawing has been obviated by appropriate amendment. "Figure 1" has been deleted from the sole drawing pursuant to CFR 1.84(u)(1). A new drawing is submitted herewith for Examiner's approval.

### CLAIM REJECTIONS UNDER 35 U.S.C. §112

The rejection to claims 2, 5, 6, 8, 11, and 12 under 35 U.S.C. §112 has been obviated by appropriate amendment and should be withdrawn. The above mentioned claims have been amended to include proper Markush language.

### CLAIM REJECTIONS UNDER 35 U.S.C. §102

For the reasons which follow hereinafter, the rejection of claims 1-12 under 35 U.S.C. §102 as being anticipated by Balema et al. has been obviated, in part by appropriate amendment, and is traversed, in part, and should be withdrawn.

Balema et al. disclose titanium catalyzed solid state transformations in  $\text{LiAlH}_4$  during high-energy ball milling. During milling, the  $\text{LiAlH}_4$  was ball-milled with a catalyst such as  $\text{TiCl}_4$ ,  $\text{Al}_3\text{Ti}$ ,  $\text{Al}_3\text{Fe}$ , or  $\text{Al}_{22}\text{Fe}_3\text{Ti}_8$ . The catalysts were ball-milled with  $\text{LiAlH}_4$  to investigate the ability of the catalysts to promote the mechanochemical transformation of  $\text{LiAlH}_4$  to  $\text{Li}_3\text{AlH}_6$ .

In contrast, the presently pending invention claims a

reversible hydrogen storage material comprising 80 to 99.9 weight percent of an aluminum hydride and 0.1 to 20 weight percent of a catalytic material comprising a hydrogen storage alloy, a Raney catalytic material, or combinations thereof. Balema et al. do not disclose a hydrogen storage material as presently claimed. In particular, Balema et al. disclose  $\text{LiAlH}_4$  including a catalyst such as  $\text{TiCl}_4$ ,  $\text{Al}_3\text{Ti}$ ,  $\text{Al}_3\text{Fe}$ , or  $\text{Al}_{22}\text{Fe}_3\text{Ti}_8$ , not a hydrogen storage material including an aluminum hydride and a catalytic material comprising a hydrogen storage alloy, a Raney catalytic material, or combinations thereof as presently claimed.

A "Raney catalyst" is a catalyst made by a Raney process which includes the step of leaching out the soluble metal, typically Al, from a Raney alloy. A Raney Alloy is a 50:50 alloy of Al and a non-soluble metal such as Ni, Fe, Co, Cu, or Mn. The leaching step may be carried out by subjecting the Raney alloy to an aqueous solution of an alkali metal hydroxide such as sodium hydroxide or potassium hydroxide. After the leaching step, mostly all of the Al is leached out of the Raney alloy thus leaving behind the insoluble component of the Raney alloy which forms the Raney catalyst. The Raney catalyst generally comprises >90% of the insoluble metal. The resulting Raney catalyst has a "skeleton" or "sponge" structure with dissolved Al, surface hydrous oxides, adsorbed  $\text{H}^+$  radicals, and/or hydrogen remaining in the pores of the Raney catalyst. Raney catalysts have been well known in the art since their

inception in the 1920's and are used primarily as hydrogenation catalysts for the synthesis of amines, alcohols, polyols, and alkanes. Raney catalysts are also used for catalyzing many other organic synthesis steps such as reductive alkylation of carbonyl compounds with amines, hydrogenolysis of esters and ethers, dehydrogenation of hydrocarbons and alcohols, dehalogenation, Desulfurization, Asymmetric Synthesis, isotope labeling. Raney catalysts have also been found to be very useful in electrochemical cell electrodes due to their high surface area. Raney catalysts do not include materials such as  $\text{TiCl}_4$ ,  $\text{Al}_3\text{Ti}$ ,  $\text{Al}_3\text{Fe}$ , or  $\text{Al}_{22}\text{Fe}_3\text{Ti}_8$ .

A reversible hydrogen storage alloy is a metallic alloy that readily absorbs and desorbs hydrogen. The reversible hydrogen storage alloy reversibly absorbs hydrogen and stores the hydrogen within its crystal structure in metal hydride form. Reversible hydrogen storage materials as disclosed in accordance with the present invention do not include materials such as  $\text{TiCl}_4$ ,  $\text{Al}_3\text{Ti}$ ,  $\text{Al}_3\text{Fe}$ , or  $\text{Al}_{22}\text{Fe}_3\text{Ti}_8$ . In particular, Al based alloys are not reversible hydrogen storage alloys. Al, however, may be used in small amounts as a modifier element for various hydrogen storage alloys, but offers no reversible hydrogen storage capability. Al is typically used as a modifier element in hydrogen storage alloys in electrochemical applications, as the Al is leached out of the alloy upon contacting an electrolyte thus increasing the porosity of the hydrogen storage alloy. Examples of reversible hydrogen

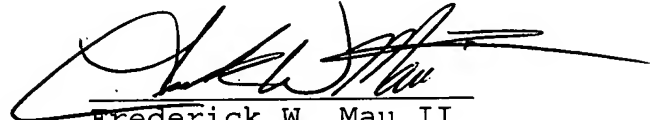
storage alloys are Rare-earth metal based alloys, Misch metal based alloys, zirconium based alloys, titanium based alloys, magnesium/nickel based alloys, and mixtures or alloys thereof which may be AB, AB<sub>2</sub>, or AB<sub>5</sub> type alloys capable of storing hydrogen in metal hydride form. By using the reversible hydrogen storage alloys as described above, the hydrogen storage material in accordance with the present invention is able to benefit from the increased reversible hydrogen storage capacity due to the reversibility and hydrogen storage capacity of the hydrogen storage alloy.

As such, the presently pending invention is readily distinguishable and clearly patentable over the cited reference and the rejection should be withdrawn.

Accordingly, Applicant submits that the present amendment places the application in condition for allowance. The Examiner is respectfully requested to pass the application to issuance.

The Examiner is respectfully invited to call the Applicants' representative should it be deemed beneficial to further advance prosecution of the application.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'F. W. Mau II', is written over a horizontal line.

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# Raney<sup>®</sup> Catalysts

Grace Davison's Raney<sup>®</sup> catalyst family is an efficient class of catalyst available for numerous organic processes including hydrogenations, ammonolysis, reductive alkylation and dehydrogenations. They are available in both slurry and fixed bed form. They are usually made from nickel, cobalt, and copper base metals. Various promoter metals (molybdenum, chromium, iron, etc.) can be added to the base metals to affect selectivity and activity. With their high activity and selective characteristics, Raney<sup>®</sup> catalysts can be an effective and economically attractive catalyst to increase process throughput while decreasing byproduct formation. Read on to find out more about general selection guidelines, description of Raney<sup>®</sup> catalysts, and key benefits of Raney<sup>®</sup> catalysts, or check out our selection of products:

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**Raney<sup>®</sup> Fixed Bed Grades**

## *General Selection Guidelines:*

Base metal activity is typically ranked in the following order: Nickel>Cobalt>Copper

Promoter metals added to base metals can affect selectivity and activity. Particle size should be optimized between activity and separation capabilities.

## *Description of Raney<sup>®</sup> Catalysts*

Origin - Selective dissolution or dissolution / reprecipitation from M-Al alloy, where (M = Ni, Co, Cu, etc.)

Composition - Mostly M (>90%), plus Al species and (optional) promoters, e.g. Mo, Cr

Structure - Extended porous "skeleton" or "sponge" of M with dissolved Al (and promoters) plus surface hydrous oxides, adsorbed H radicals and hydrogen bubbles in pores

Value - Ready-to-use hydrogenation catalyst for synthesis of amines, alcohols, polyols, alkanes, etc. from unsaturates

## *Key Benefits of Raney<sup>®</sup> Catalysts*

Readiness-for-use (requires no reduction or other activation)  
Low cost vs. precious metals  
High metal surface area leading to high activity  
Chemical durability in wide range of environments  
Relative ease of separation from product (high density)  
'Customizability' of composition  
'Customizability' of particle size distribution

*All Raney® catalyst products can be customized to maximize application efficiency.*

**Contact us to assist you in your catalyst selection.**

Raney® is a registered trademark of W.R. Grace & Co.

For more information, please **contact us!**

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# Raney® History

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*The Man...Murray Raney*

*It was a casual conversation with a co-worker that changed Murray Raney's life and, eventually led to his revolutionizing chemical processes in industries as varied as petroleum, pharmaceuticals, food and plastics.*

During the course of his first job in a furniture factory, Murray Raney, (born the son of a construction contractor in Carrollton Kentucky, 1885) who described himself as "only a whisper away from a juvenile delinquent" in talking with some of his co-workers, wondered if he too would be doing the same job after twenty-five years. He decided then that he needed an education and took several correspondence

His experiences with the supported nickel catalyst then used for the hydrogenation of vegetable oil, prompted him in 1920 to search on his own for a more active catalyst. He achieved this in 1924 when he discovered that catalytically active nickel could be produced from nickel alloys. The catalyst thus produced is known throughout the world as Raney® Catalyst. Between 1925 and 1961 he was granted six US and five European patents covering the preparation of his catalyst.

Shortly after his retirement from Gilman Paint and Varnish Co., he founded The Raney Catalyst Co. of South Pittsburg, TN. This was the start of the Raney® Catalyst product line that, (after being acquired in 1963 by W.R. Grace & Co.-Conn.), still operates under the Grace Davison banner.

Murray Raney was the recipient of the 1960 "Distinguished Service Award" of the Chattanooga Section American Chemical Society. In 1964, he was the recipient of the University of Kentucky "Distinguished Alumni Centennial Award."

From the time it was first introduced until the present day, the use of Raney® nickel has brought about important changes in the areas of organic synthesis and organic chemicals production.

school courses while continuing to work. Mr. Raney made the decision to become a pattern maker in the automobile industry and enrolled at the University of Kentucky for a summer course.

He did so well that the Dean of the School of Engineering encouraged him to continue his education. Soon after that, the professor of electrical engineering hired him as an assistant to fill a vacancy. This was quite a feat for someone who had never attended high school. In fact, never having graduated from high school left Raney with a life long feeling that he was "uneducated," although he graduated from college in 1909 with a degree in mechanical engineering.

Murray Raney's responsibility for the production of hydrogen and its use in the catalytic conversion of liquid vegetable oil to solid fats at Lookout Refining Co., led him to his interest in catalysts.

In 1935 Leopold Ruzicka reported a method for preparing androsterone and testosterone, male sex hormones, from cholesterol in which Raney® nickel played an important role. Later in 1939, he and Adolph Butenandt shared the Nobel prize in chemistry for the discovery. The catalyst was also used in the study to elucidate the structure of penicillin and the preparation of Atabrine, a drug used during the second World War as a substitute for quinine in the treatment of Malaria. Today

Raney® nickel is used in a wide variety of chemical processes to produce chemicals used in the processing of petroleum and food products and in the production of pharmaceuticals, plastics, resins, and surfactants.

Raney® catalysts have been studied by the leading scientists throughout the world. Several thousand articles referring to the catalyst have appeared in literature over the past fifty plus years.

Samples of the various Raney® catalysts and alloys are on display at the Chandler Museum of Colombia University.

As Mr. Raney said in an interview a few years before his death. "I was just lucky...I had an idea for a catalyst and it worked the first time."

Excerpts from Grace Davison literature and  
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